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Combustion Engine With A Small Volume Catalytic Converter

Background of the Invention

The present invention relates to a combustion engine with a given displacement H and with a downstream catalytic converter for cleansing of exhaust gases. According to the legal requirements of most countries, it is normal to cleanse the exhaust gases from combustion engines by means of a catalytic converter that is arranged in the exhaust system of the combustion engine.

The design of exhaust gas cleansing systems in the past was mostly based on empirical evidence. In WO 91/01178, exhaust gas cleansing systems are described, for example, which are constructed from a plurality of honeycomb bodies, so that using the size and number of these honeycomb bodies, a desired catalytic converter area could be selected for any size of displacement in a combustion engine. It is important with this, that in the end the exhaust gas is cleansed sufficiently for the legal requirements to be satisfied. This means that today in most countries more than 98%, and preferably even more than 99%, of the harmful content of the exhaust gas, in particular the hydrocarbon substances and/or nitrous oxide, are converted into harmless components. The effectiveness E is measured using specific, pre-determined driving cycles or in specific operating conditions.

The criteria to be considered when designing an exhaust gas cleansing system are most numerous. Catalytic converters typically include honeycomb bodies, which have the task of making available a sufficiently large geometrical surface with which the exhaust gas to be cleansed comes into contact. The honeycomb bodies are generally provided with exhaust gas permeable channels that are separated from one another by walls. The geometric surface O is crucial to the effectiveness E of a catalytic converter. In principle, a specific desired

geometric surface O can be obtained by enlargement of the number A of walls in a pre-determined volume, or by enlargement of the volume while having a pre-determined number A of walls per cross-sectional unit. The design must also take into account the flow speed and flow characteristics in the channels which affect the effectiveness E, and the pressure loss in the exhaust gas flow caused by the catalytic converter, which loss influences the degree of efficiency of the combustion engine. Naturally, the design of the cross-sectional shape of the honeycomb body depends on the type of catalytically active coating, the flow to the honeycomb body, and other parameters.

As a result of further development of honeycomb bodies as supporting bodies for catalytically active material in a catalytic converter, the wall thicknesses of the channels are being reduced more and more, which has a positive effect on the pressure loss. The freedom in designing is ever greater because, with reduced wall thickness, ever smaller channels and ever larger geometric surfaces per volume unit can be produced, with an acceptable pressure loss. Nevertheless, the rules discovered empirically are still substantially retained, so, typically, with combustion engines the volume of a downstream catalytic converter is of the same order of size as the displacement.

SUMMARY OF THE INVENTION

An aim of the invention is to provide a combustion engine with a downstream catalytic converter, in which the catalytic converter is designed such that it reaches a legally required high degree of effectiveness E, but has a significantly smaller volume V than the displacement H of the combustion engine, and can be manufactured more inexpensively.

In accordance with the invention, a combustion engine is provided, with a downstream catalytic converter. The combustion engine has a displacement H. The downstream catalytic converter is provided for cleansing exhaust gases. The catalytic converter has a geometric surface O. The

catalytic converter has an effectiveness E for converting at least one harmful component in the exhaust gases into harmless components. The catalytic converter includes at least one honeycomb body. The honeycomb body has, or where there is more than one the combination of honeycomb bodies have together, a total volume V. The volume V is such that it is smaller by at least a factor of 0.6 than the displacement H, while the geometric surface O is dimensioned such that the catalytic converter has an effectiveness E of more than 98%.

These requirements are expressed by the formulae:

(a) $E > 98\%$

(b) $V < 0.6H$

This selection of parameters has, on the one hand, the advantage that the catalytic converter requires only a relatively small volume, which facilitates its accommodation in the engine space and/or below the floor tray of a motor vehicle. Naturally, the geometric surface O per volume unit must be increased compared to large volume catalytic converters, in order to obtain the necessary effectiveness E. While it was previously assumed that the thinner channel walls necessary for this increased the costs for manufacturing smaller volume honeycomb bodies with larger geometric surfaces, an precise analysis unexpectedly shows that this is not the case, as will be explained hereinafter, in particular with reference to honeycomb bodies manufactured from metallic foils.

It is particularly advantageous when the number A of channels in the cross-section of the honeycomb body is at least 500 cpsi (cells per square inch). The thickness d of the channels walls, which separate the channels from one another, must on average be at most 40 micrometres, preferably 35 micrometres, and particularly between 18 and 32 micrometres.

(c) $A >= 500$ cpsi

(d) $d < 40$ micrometres

With metallic honeycomb bodies of layered and/or wound, at least partially structured, sheet metal layers, there is a relationship between the number A of channels per cross-sectional surface of the honeycomb body and the thickness d of the sheet metal layers. With relatively few channels per cross-sectional surface, the channels themselves have relatively large dimensions, so the channel walls have to be relatively thick so that they do not oscillate in the pulsating exhaust gas flow and in the long term become damaged. The smaller the channel cross-sections are, the shorter the freely oscillating sections of the structured sheet metal layers which form the channel walls. The sheet metal layers can therefore be thinner without increasing the tendency to oscillate. This effect is very important for the present invention, as larger numbers A of channels per cross-sectional surface can only be implemented, having regard to undesirable pressure losses, when the channel walls are very thin.

As, because of resistance to corrosion, only steel sheets with a high chromium and aluminium content are used for catalytic converters, which are relatively difficult to roll, the skilled person correctly assumed that the manufacturing costs for such steel foils increase as the foil becomes thinner. Close examination shows, however, as will be explained in more detail with reference to Figure 3, that actually the price for the geometric surface O, upon which the effectiveness E of the catalytic converter substantially depends is less, the greater the number A of channels per cross-sectional unit in a honeycomb body, when the thickness d of the foils is correspondingly reduced. The unexpected finding of the present invention is therefore that, at least for metallic honeycomb bodies, the costs for obtaining the necessary effectiveness of a catalytic converter reduce, the greater the ratio of the number A of channels per cross-sectional area to the volume V of the honeycomb body, as long as in each case the thickness d of the foil is reduced to the extent possible as a result of the tendency to oscillate. While naturally, the price per litre of catalytic converter volume increases in an almost linear manner with the number A of channels per cross-sectional

unit in this volume, and therefore greater numbers A of channels would not necessarily be seen as cost effective, an increase in the number A of channels and simultaneous reduction in the volume V is particularly advantageous.

From these points of view, according to the invention honeycomb bodies in particular with at least 600 cpsi, and an average thickness d of the channel walls of at the most 32 micrometres are proposed.

BRIEF DESCRIPTION OF THE DRAWINGS

Hereinafter, the invention will be described in more detail with reference to the drawings. There is shown in:

Figure 1 a combustion engine with a downstream catalytic converter,

Figure 2 a schematic view in perspective of a catalytic converter, and

Figure 3 a diagram for illustrating the price of volumes and respectively of surfaces in a metallic honeycomb body, dependent upon the number A of channels per cross-sectional unit.

DESCRIPTION OF PARTICULAR EMBODIMENTS

Figure 1 shows a combustion engine 1, downstream of which there is a catalytic converter 2. Typically, such a catalytic converter 2 is constructed from one or more honeycomb bodies, and arranged in the engine space or under the floor tray of a motor vehicle.

Figure 2 shows a catalytic converter 2, which contains a honeycomb body 3. In the present embodiment of the invention, to which said invention is, however, not limited, this honeycomb body 3 is constructed of alternate flat 6 and corrugated 7 sheet metal layers, which form channels 4. The

sheet metal layers 6, 7 form the channel walls 5 with an average thickness d. The sheet metal layers 6, 7 together form the geometric surface O of the honeycomb body 3. The sheet metal layers 6, 7 are, however, coated with a ceramic, aluminium oxide based, so-called washcoat, whereby a very large porous surface is produced, which can be many times greater than the geometric surface O. A catalytically active substance, in particular a mixture of different noble metals, is applied to the washcoat, which is not shown.

Figure 3 shows in a diagram the number A of channels 4 per cross-sectional surface unit (cpsi) on the x-axis, while on the y-axis, on the left-hand side the price per honeycomb body volume (price per litre) is shown, and on the right-hand side the price per area (price per square metre). By means of vertical lines, the ranges are shown in which thicknesses d of metal foils typically available on the market can be used. It is evident that for up to 500 psi, metal foils of 50 micrometres thickness are particularly suitable, for 500 - 600 cpsi, of 40 micrometres thickness, and for 600 - 800 cpsi, foils of 30 micrometres thickness, wherein for even larger numbers of channels per cross-sectional unit, even thinner foils should be used. The line P1 in the diagram shows how the price per litre increases with an increasing number A of channels 4 per cross-sectional unit. Of more importance to the present invention, however, is that the curve P2 shows how the price per square metre decreases with an increasing number A of channels 4 per square metre. For honeycomb bodies according to the invention, this means that while having the same geometric surface O, a smaller volume honeycomb body with a large number of channels is cheaper than a honeycomb body with a larger volume.

The present invention thus teaches the cost effective use of small volume catalytic converters with a large number A of channels 4 per cross-sectional surface, in particular the use of metal foils of a thickness of on average approximately 25 micrometres, or even 20 micrometres for honeycomb bodies with more than 800 cpsi, up to 1200 cpsi. With such honeycomb

bodies, an effectiveness of 98%, preferably even 99% is obtained, even when the volume V of a catalytic converter 2 connected downstream to a combustion engine 1 is only half or less of the displacement H of the combustion engine 1.

Although particular embodiments of the invention have been described, it will be appreciated that many modifications/additions and/or substitutions may be made within the spirit and scope of the invention as defined in the appended claims.

List of designations

1 combustion engine
2 catalytic converter
3 honeycomb body
4 channel
5 channel wall
6 flat sheet metal layer
7 structured sheet metal layer

A number of channels
d thickness of the channel wall
H displacement
E effectiveness
O geometric surface
V volume

P1 price per volume unit
P2 price per geometric surface unit